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Before the
Federal Communications Commission
Washington, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

In the Matter of	)	
	)	
Review of the Commission's	)	MM Docket No. 00-39
Rules and Policies	)	
Affecting the Conversion	)	
To Digital Television	)	

COMMENTS OF NXTWAVE COMMUNICATIONS, INC.

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May 17, 2000

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EXECUTIVE SUMMARY

NxtWave has analyzed the DTV Standard in detail, and concluded that it and the 8-VSB modulation it employs are capable of meeting or exceeding the Commission's goals in terms of coverage, data rate, and extensibility for new applications. The reasons for initial receiver problems that some experienced have been addressed by improved chips and technology that will arrive in the consumer market from NxtWave and multiple other competing vendors in the coming months.

Recently, requirements have been suggested that would require transmission of auxiliary data with the normal broadcast program payload. The ATSC format can support this use even with portable devices. NxtWave engineers have developed a two-tiered ATSC-compliant extension that multiplexes more robust data packets with standard packets so that there is no effect on existing equipment.

Considering non-compatible changes to the DTV Standard, or a different standard altogether, at this late date would only confuse the marketplace, delay the transition, and prevent timely recovery of the analog spectrum. The marketplace has provided substantial incentives to solve early reception difficulties. Multiple vendors, including NxtWave, have invested substantial resources and now have second generation chips and sets that enable excellent DTV reception.

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Comments of NxtWave Communications, Inc.

NxtWave Communications Inc., pursuant to Section 1.415 of the Commission's Rules,[1] respectfully submits these comments in response to the *Notice of Proposed Rulemaking* in the above-captioned proceeding.[2]

I. Introduction

The U.S. digital broadcast standard was designed to cover the service areas of existing analog stations, and to do so carrying the maximum feasible data rate using channels of 6 MHz bandwidth. After detailed analysis, NxtWave concluded that the DTV Standard and the 8-VSB modulation it employs is capable of meeting or exceeding these goals in terms of coverage, data rate, and extensibility for new applications. No compelling technical reason exists to consider changing the standard. The initial receiver problems that some experienced have been addressed by improvements to receiving circuitry that ensure robust, reliable reception. These improvements will arrive in the consumer market from multiple competing vendors in the coming months.

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1 47 C.F.R. § 1.415 (1999).

2 *Notice of Proposed Rulemaking* in MM Docket No. 00-39 (rel. March 8, 2000) (*"NPRM"*).

II. Statement of Interest

NxtWave Communications, Inc. (NxtWave) is a communications technology company that designs and markets broadband integrated circuits (chips) for use in digital devices. NxtWave chips are designed to be used to receive broadcast and cable signals in digital television sets, set-top boxes (including those used with cable and satellite), personal computers, digital video recorders, and any other device intended to receive and decode over-the-air or cable signals. NxtWave designed and markets its multimode VSB/QAM demodulator chip to demodulate both over-the-air ATSC-compliant digital signals and the 64/256 QAM digital cable signals. NxtWave also employs engineers with substantial expertise with COFDM modulation, and shortly will announce its COFDM chip for the European DVB market.

III. Background

In this proceeding, the Commission requests comment on the current status of the DTV Standard. The Commission expressed particular interest in the progress being made to improve indoor DTV reception and manufacturers' efforts to implement DTV design or chip improvements.[3] These are the areas of NxtWave's expertise, and we address these issues below.

In 1998/1999 NxtWave understood that reception of ATSC-compliant signals was not meeting its theoretical limits. NxtWave analyzed the reasons for the unusually high number of disruptions to reception, specifically analyzing whether something intrinsic to the standard itself was the cause or whether there were basic problems with implementing the Standard in transmitters and receivers. We concluded that the standard itself is sound

[3] *NPRM* at ¶ 8.

and fully capable of delivering the service intended. While transmission issues have arisen, they are readily correctable.

Receivers, however, were having difficulty decoding signals under certain multipath conditions even with transmissions that met ATSC specifications. These problems tended to occur close to the transmitter (within 7 or so miles) in urban areas where tall buildings or nearby mountains reflect signals in multiple rays. NxtWave focused its efforts upon quantifying the causes for the reception difficulties with certain receivers and implementing new designs in its decoder chips to facilitate better reception.

NxtWave's analysis of the first receiver designs and decoder chips concluded that they did not deal adequately with actual over-the-air signal reception in some situations, including certain multipath environments. But equally as important, NxtWave's analysis found that reception IS enabled by the DTV Standard; receiver implementation, not the standard itself, required improvement. Our conclusion was, and continues to be, that the ATSC standard provides a robust signal that is readily viewable with appropriate decoding and has certain advantages for the U.S. market, as described in Section IV.

Beginning in 1998, NxtWave therefore devoted significant resources to developing better demodulation chip designs to meet what it perceived would be consumer demand for better over-the-air reception than provided by early consumer equipment implementations. NxtWave's first chip, the NXT2000 announced in August, 1999, exceeded the performance of previous ones in the market. Based upon experience with its first chip, NxtWave is designing improvements into its second chip scheduled to be available in the fourth quarter of 2000. Like other chipmakers in this very competitive field, we are racing to produce future generations of chips in order to ensure that consumers achieve flawless reception that replicates the theoretical coverage of the standard.

NxtWave also concluded that broadcasters, like all sectors of the communications industry, must digitize; and that the DTV Standard adopted by the Commission in December, 1996 should continue to be supported by regulators as well as by the industry. Continued adherence to the standard will avoid unnecessary delay in rolling out digital services to the public. U.S. broadcasters will be able to make the digital transition sooner, at lower cost, and at lower risk than that provided by any other path.

More recently, NxtWave participated in meetings at the ATSC to address the capabilities and reception issues associated with the DTV Standard. NxtWave has had numerous discussions with all sectors of the affected industries, including broadcasters. This has lead NxtWave to understand that some broadcasters are considering business models that contain new services, such as datacasting, intended to reach portable, and even mobile, receivers. NxtWave is fully prepared to work with interested parties and devote its substantial expertise to enabling these applications by using the most efficient methods that are backward compatible with the FCC-adopted DTV Standard.

NxtWave is a technology enabler. The DTV Standard was not designed for some of the applications now being envisaged. That decision was made NOT because doing so was impossible, or even difficult; rather, at the time broadcasters and other stakeholders were not interested in such applications, and instead elected to emphasize maximum capacity (data rate) and efficient coverage.

IV. The ATSC Standard Has Specific, Concrete Advantages for the U.S. Marketplace

The DTV Standard is the best path to a quick transition to digital broadcasting. Considering changes to the standard without compelling technical reasons will confuse the marketplace, delay the transition, and prevent timely recovery of the analog spectrum.

Contemplating a different standard now would require completely redoing the Commission's Table of Allotments, accepting substantial new interference to signals within each station's service area, OR reducing powers and service areas to protect from harmful interference. The specific technical attributes of the DTV Standard determined the details of the Commission's technical analysis and channel assignment set out in its DTV Table of Allotments.[4] A modulation scheme with different carrier-to-noise power requirements would require a new Table based upon the characteristics of the new modulation scheme.

For example, the most recent comparative tests between the U.S. DTV standard and that of Europe confirmed previous tests that a 3-5 dB difference exists with regard to the signal strength needed to receive the signal. This increase in power would create additional interference not heretofore contemplated unless either (1) broadcasters agree to keep their maximum powers at previous levels, in which case signals to suburban and rural areas will fall off before the stations' NTSC signals; or (2) stations will be required to tolerate the increased interference from other stations. Neither of these scenarios augurs well for a rapid and successful transition to digital television.

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[4] *See* Advanced Television Systems and their Impact upon the Existing Television Broadcast Service, 14 FCC Rcd 1348 at 1394 *et seq.* (1998) (DTV Table of Allotments).

V. Chip Designs Improve Performance

The NXT2000 is a high–speed demodulator chip that was introduced in August 1999 for Digital Television (DTV) broadcast and cable receivers. For terrestrial broadcast of digital signals compliant with the Advanced Television Systems Committee (ATSC) Standard, the NXT2000 demodulates 8 Vestigial Sideband Modulation (VSB). For cable deployment of DTV signals, the NXT2000 demodulates both 64- and 256-Quadrature Amplitude Modulation (QAM), and 16-VSB.

Both broadcast and cable transmissions introduce distortions to the transmitted signal. If the error tolerance of the system is exceeded, reception can fail completely. To correct for these distortions and restore signal quality, the NXT2000 uses advanced equalization, synchronization, and error correction techniques that were designed in 1998.

NxtWave's second-generation ATSC demodulator chip will be available in the fourth quarter of 2000. This chip will significantly advance reception capabilities in severely-distorted, time-varying propagation conditions. These performance improvements are due to advances in channel equalization. Studying reception of the multiple broadcast signals that became available with the roll-out of digital signals starting in November, 1998 has greatly facilitated analyses of reception conditions.[5]

Improvements in equalization provide for enhanced inter-symbol interference (ISI) cancellation and tracking capabilities. For example, the graph in Figure 1 shows the required Carrier-to-Noise Ratio (CNR) at Threshold of Visibility (TOV) versus echo level when the echo is at a delay of +1 usec relative to the desired signal. Figure 1 shows performance curves for four systems: the current generation ATSC-professional unit, the

NxtWave second-generation chip, and 2K/8K COFDM modes compliant with the European DVB-T standard.

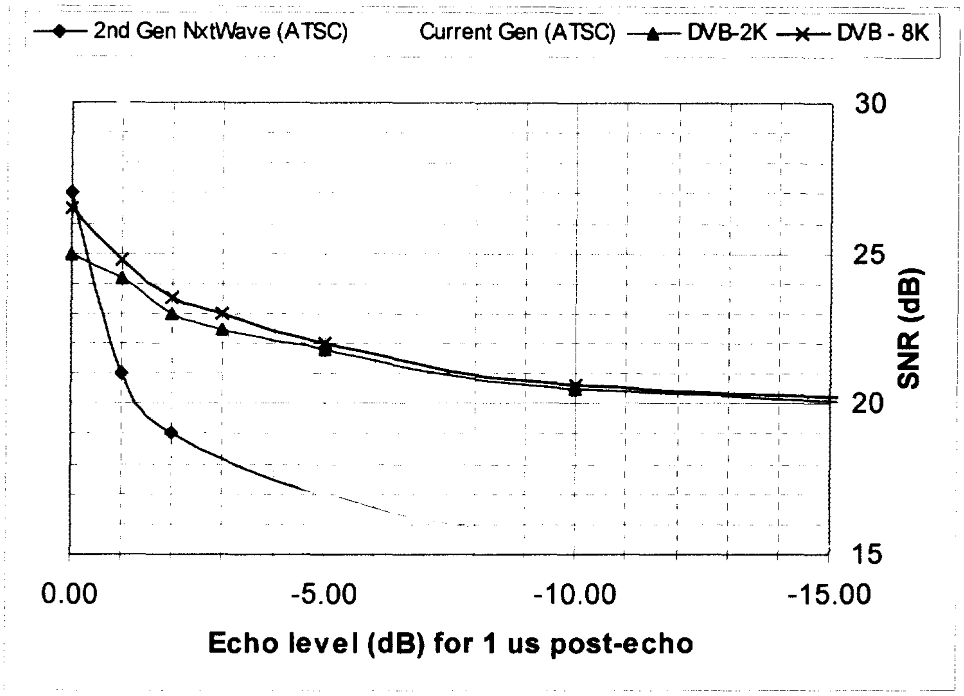

Figure 1: These curves show the CNR required to reach TOV of four systems with a single echo at +1 usec. DVB-T and ATSC data is from Brazil laboratory measurements. NxtWave second-generation chip data is obtained using sampled RF data that is passed into a computer model of the chip.

Observe from Figure 1 that the penalty in CNR paid by the DVB-T systems requires about 20 dB CNR for small echoes, while the ATSC system can operate in a CNR about 5 dB lower. Observe further that the NxtWave second-generation chip is capable of correcting a 0 dB echo, dispelling the myth that the ATSC Standard cannot work with 0 dB echoes. This capability will be important if on-channel repeaters (or gap fillers) are used for the penetration of terrestrial HDTV signals into areas more geographically amenable to cable transmission. Note that the use of on-channel repeaters

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[5] The NXT2000 was developed prior to the availability of off-air DTV signals.

for ATSC does not require highly complex synchronization schemes as required for multi-carrier systems.

A similar experiment for the same four systems is described by Figure 2. Here the echo is time-varying due to a doppler shift of the radio frequency (RF) carrier. The maximum echo level at TOV is measured versus the rate of doppler frequency offset for an echo at a delay of +4 usec.

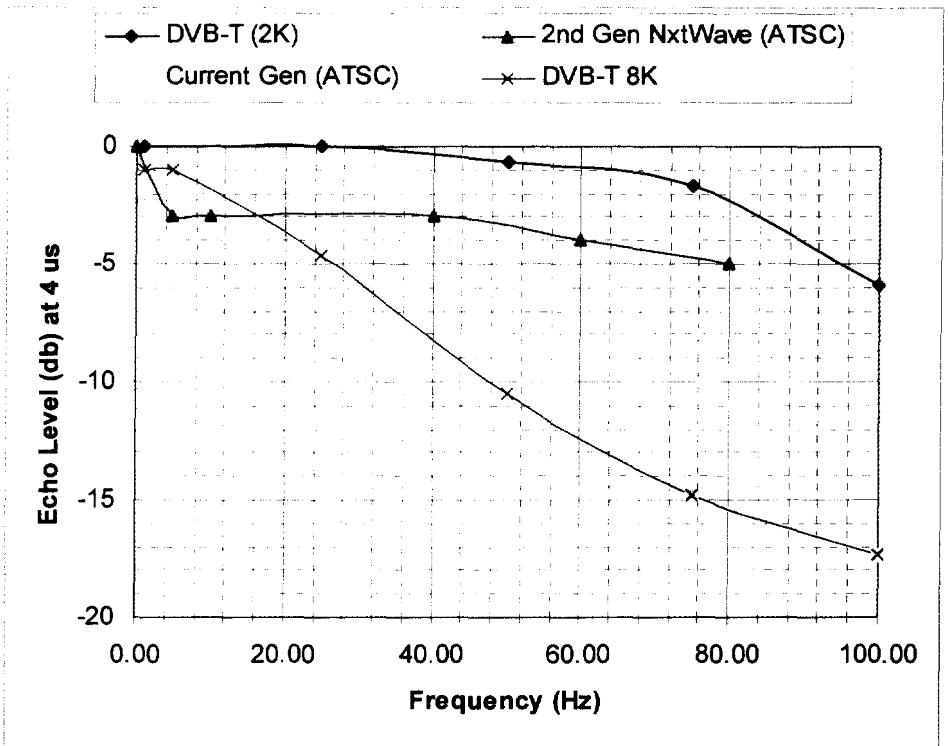

Figure 2: These curves show performance of four systems when a single echo at +4 usec suffers a doppler frequency offset.. DVB-T and ATSC data is from Brazil laboratory measurements. NxtWave second-generation chip data is obtained using sampled RF data that is passed into a computer model of the chip.

Observe from Figure 2 that the NxtWave second-generation chip is within 3 dB of the 2K DVB-T mode, and out-performs the 8K DVB-T mode in most regions. The NxtWave second-generation chip also out-performs the current generation ATSC receiver in all regions. The results depicted in these two figures demonstrate that the

NxtWave second-generation chip will enable ATSC-compliant reception by portable devices such as laptops and hand-held communicators.

To accomplish the superior 8-VSB performance in Figures 1 and 2 and maintain cost-effective silicon implementation, NxtWave engineers collected and analyzed numerous data records from over-the-air DTV broadcasts. The equalizer architecture, sparse-allocation algorithm, and hardware implementation of the NXT2000 are modified in the NxtWave second-generation chip for substantially improved indoor reception. NxtWave engineers also have developed, and continue to develop, advanced architectures and algorithms that will be economically realizable in 0.18 micron silicon. This trend is analogous to the 5-year old 300 baud modem that has evolved into today's 56 kilobaud standard, as predicted by Moore's Law. NxtWave's future generations of demodulators in 0.18 micron silicon will be less constrained than current 0.25 micron silicon and therefore use more sophisticated and accurate signal processing solutions. This will provide consumers with nearly-unbreakable ATSC reception.

The results for the NxtWave second-generation chip indicated in Figures 1 and 2 are based on simulations with a reference model that is used as the mathematical blueprint of the chip. This reference model is both bit- and cycle-accurate. The chip is built to exactly match the operation of the reference model in a variety of configurations, thus allowing accurate performance prediction. This same procedure was used to predict the performance of the NXT2000 (for example, see "IC cracks the code to improved digital TV reception," *Electronic Design*, pp. 35-39, August 23, 1999, at Appendix A). Table 1 shows some performance data points for the NXT2000, both predicted by simulation, and later measured with silicon at the ATTC laboratory.

Table 1: Performance of the NXT2000 predicted by simulation and measured at the ATTC laboratory

Multipath Description	Offset from CNR = 15 dB required at TOV	
	NXT2000 measured by ATTC	*NXT2000 predicted by simulations*
No multipath (purely noise)	0 dB	-0.1 dB
ATTC Ensemble-A	+1.02 dB	+1.2 dB
ATTC Ensemble-B	+0.8 dB	+0.9 dB
ATTC Ensemble-C	+1.26 dB	+1.2 dB
ATTC Ensemble-D	+1.23 dB	+1.2 dB
ATTC Ensemble-E	+1.39 dB	+1.5 dB
ATTC Ensemble-F	+0.96 dB	+0.9 dB

Note that the predicted and measured performance are within about a tenth of a dB, or within the error margin of the measurement.

The data used to drive the reference model in Figures 1 and 2 was recorded with an RF (radio frequency) capture device using a first generation tuner. Therefore, our predictions for the performance of the NxtWave second-generation chip include the effects of phase-noise and other non-ideal system characteristics. These results show significant improvement compared to first-generation receivers, whose limitations have hampered early field tests and misguided conclusions surrounding the ATSC Standard.

More recent field tests conducted independently by CBS (reported in "DTV Reception Field Tests," *National Association of Broadcasters*, Las Vegas, NV, April 12, 2000) used the NXT2000 and other current generation demodulators. These tests conclude that the current generation ATSC-compliant receivers already replicate viewable analog NTSC coverage. Moreover, since the demodulator chip is only one component of a highly-integrated system, albeit a key component, improvements in other system areas such as the RF tuner, together with a competitive industry fueled by the potential of an emerging market, guarantee that future generation receivers will provide the consumer with exceptional ATSC-compliant reception.

When the ATSC Standard was adopted in 1996, the broadcast community did not express any desire to implement a hierarchical modulation to facilitate a multi-tiered service. Instead, they chose a fixed-point, maximum data-rate transmission standard. The physical layer of the standard therefore was designed with a fixed format, but the packetized transport layer supports flexible service.

More recently, the requirement has appeared to simultaneously transmit auxiliary data with normal video/audio payload. The ATSC format can support flexible insertion of encoded auxiliary data packets that can be received with portable devices without disrupting the existing installed base of consumer receivers. NxtWave engineers have developed a two-tiered ATSC-compliant extension that multiplexes more robust data packets with standard packets so that there is no effect on existing transmitters and receivers. The robust data packets simultaneously carry information and enhance the equalizability of the entire ATSC-compliant signal. Proposals to insert training packets that do not carry information excessively reduce the data throughput of the 6 MHz VSB signal. Instead, a two-tiered service is possible with robustly-encoded packets that can be received within TOV error rates while operating in a CNR well below the standard 15 db that is required for standard packets. This is in contrast to the DVB-T standard where the hierarchical modulation increases the required CNR to maintain TOV error rates for the standard data packets.

VI. Conclusion

As discussed above, sound technical analysis of DTV reception indicates that issues with consumer reception relate to implementation rather than to any basic flaw in the DTV Standard. The marketplace has provided substantial incentives to solve reception difficulties, and multiple vendors have invested substantial resources to design better chips and sets. Digital reception using the DTV standard therefore may have been yesterday's problem, but left to the marketplace, it will be tomorrow's success.

Respectfully Submitted,

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May 17, 2000

Appendices

A. Comments of NxtWave Communications on FCC Office of Engineering and Technology DTV Report (FCC/OET 99-2)

B. Electronic Design, August 23, 1999

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NxtWave
COMMUNICATIONS

November 9, 1999

Mr. Dale Hatfield, Chief
Office of Engineering and Technology
Federal Communications Commission
445 Twelfth Street, SW
Washington, DC 20554

Dear Mr. Hatfield:

NxtWave has reviewed OET's comprehensive *DTV Report on COFDM and 8-VSB Performance*, FCC/OET 99-2 (dated September 30, 1999). NxtWave agrees with the conclusions of OET's technical analysis.

The 8-VSB Standard has a number of advantages over a COFDM standard, including better carrier-to-noise threshold, and contrary to Sinclair's assertions, there is no threshold penalty due to the use of blind equalization. The 8-VSB Standard also results in higher spectrum efficiency, lower peak-to-average power ratio, and less susceptibility to impulse noise and phase noise. For these and the additional reasons explained in NxtWave's comments, there is no reason for the Commission to consider modifications to the DTV Standard that it adopted in December, 1996. Re-opening the standard would result in needless years of delay and inevitable marketplace confusion.

Sincerely,

Matthew D. Miller

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President & Chief Executive Officer

Enclosure

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Comments of NxtWave Communications on FCC Office of Engineering and Technology DTV Report (FCC/OET 99-2)

November 9, 1999

Introduction

NxtWave Communications, Inc. (NxtWave) hereby addresses the comprehensive *DTV Report on COFDM and 8-VSB Performance* dated September 30, 1999, prepared by the Commission's Office of Engineering and Technology (OET). NxtWave agrees with the conclusions of OET's technical analysis, and herein submits additional information supporting the report's conclusions regarding the capabilities of 8-VSB systems.

Background

NxtWave Communications, Inc. (NxtWave) is a communications technology company that designs and markets broadband communications integrated circuits (ICs) for use in digital televisions, digital video recorders, personal computers, and cable modems. NxtWave's mission is to provide high-performance, low-cost integrated circuit (IC) chips that enable mass markets for broadband communications. The Company recently introduced the NXT2000[1], a multimode VSB/QAM demodulator chip aimed at the emerging North American digital television market. This chip demodulates both 8-VSB over-the-air digital transmissions and 64/256 QAM digital cable signals.

NxtWave was spun off by Sarnoff Corporation in 1996. The Company changed its name from Sarnoff Digital Communications, Inc. to NxtWave Communications, Inc. in 1999. The Company has had two rounds of venture capital financing. The most recent investment round, totaling $13.6 Million, was announced September 20, 1999[2]. The investment round, which was led by Venture First Associates[3], included additional investment by first round investors Blue Rock Capital, Mid-Atlantic Venture Funds, and

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[1] See NxtWave press release August 24, 1999 (attached).

[2] Although publicly announced on September 20, 1999 after the investment round had concluded, the terms and conditions of the equity sale were arrived at in January 1999. The initial closing and funding occurred at the end of March 1999. Over the next few months, equity sales to other venture capital and strategic investors closed at various dates before September 1, 1999. See NxtWave press release September 20, 1999 (attached).

[3] Venture First Associates operates a number of venture capital limited partnerships. The investment in NxtWave was made by HVFM VI, in which Harris Corporation is a limited partner. Harris has neither direct ownership interest nor governance in NxtWave. The ownership interest of HVFM VI in NxtWave is less than 20%. See also Harris Corporation 1999 Annual Report (p.15) regarding Venture First.

Oak Investment Partners. Anadigics, Inc., Dimensional Partners, Intel Corporation, Pequot Capital Management's venture fund, PS Capital Ventures, LP and J. H. Whitney & Company also participated in the financing.

Advantages of the ATSC Standard

Systems based upon 8-VSB or COFDM each inherently have different advantages and disadvantages that derive from their design parameters and technical characteristics. During the extensive evaluation and testing period that preceded selection of the U.S. standard all relevant operating parameters were considered on their technical merits. 8-VSB was selected because of advantages in power, spectrum efficiency, coverage, resistance to interference, and cost.

A recent technical analysis[4] confirms these beneficial attributes. The analysis compares the ATSC standard based upon 8-VSB to the DVB-T standard based upon COFDM. The ATSC transmission system was confirmed to have better carrier-to-noise threshold resulting in larger service areas per unit of power used, higher spectrum efficiency (a higher data throughput in a given channel), lower peak-to-average power ratio (important for power and coverage), and less susceptibility to impulse noise and phase noise. The impulse noise resistance is particularly important to reception of VHF channels 2-13, which provide large service areas with superior coverage in suburban and rural communities. The phase-noise resistance of 8-VSB is important in the U.S. where a very wide spectrum range (from VHF to UHF) must be tuned by a single tuner.

In 1996, the FCC adopted most aspects of the industry-recommended ATSC DTV Standard following a comprehensive, scientifically thorough and exhaustive process. The U.S. is a large nation with an extensive system of existing analog broadcast stations, which even within the same metropolitan area, often are spread among multiple locations. Compared to the DVB-T COFDM system (which is one of several existing COFDM-based television standards), the ATSC transmission standard is best for U.S. broadcasters because it provides a larger coverage area at less operating expense, a higher data payload within the 6 megahertz channels that are standard in the United States, superior interference protection both to and from existing analog television services, and substantially improved protection from impulse and phase noise.

Any consideration of COFDM as an additional standard first must consider that there is no evidence in the record indicating a deficiency in the transmission standard adopted by the Commission. In the record, at its most liberal reading, there is only anecdotal evidence of reception difficulties using two specific first-generation receivers. Addressing the transmission standard by considering adoption of multiple standards not only is totally unsupported in the record, but would require ignoring the substantial information in the record that (a) the ATSC 8-VSB standard is fully capable of providing

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[4] See Y. Wu, IEEE Transactions on Consumer Electronics, August 1999. (Dr. Wu is a senior research scientist with the Communications Research Center in Ottawa, Canada.)

reception in most environments, (b) in reliance upon the Commission's adoption of the 8-VSB standard many companies, including NxtWave, have invested millions of dollars to develop and improve the technology, and (c) chips have been manufactured that significantly improve performance.

Delay Would be Substantial

It also must be considered that there is no single COFDM standard today, and none exists that is designed for a 6-megahertz channel and the U.S. interference environment. There are several different COFDM standards adopted in different countries, each with its own peculiar characteristics designed to meet the environment in which it is intended to be used. None is designed for the 6-megahertz channel bandwidth used in the U.S. for both analog and digital broadcasting, and the specifications (such as data capacity) of one that complies with U.S. technical rules are not known.

It would require no less than two years to define a 6-megahertz COFDM standard appropriate for use in the U.S. Following complete specification, it would take about a year to design, fabricate, test, and qualify demodulator integrated circuits for receivers. Following the qualification of the ICs by consumer electronics manufacturers, it would be about another nine to twelve months before consumers could purchase receivers containing the new ICs. This time to market is the norm for new consumer electronics product design, manufacturing and distribution. The lengthy process of defining a new standard and developing marketable products would result in needless delay as well as inevitable market-place confusion.

Finally, the substantial chilling effect must be considered that such consideration would have in a marketplace where substantial quantities of studio and home consumer digital equipment and programming are just beginning to be rolled out. Studios and broadcasters have made substantial investments in the future of digital programming in reliance upon the Commission's representations that it had finished its consideration of standards issues and the marketplace now would be left to work.

Industry is Addressing the Multipath Issues Identified in the OET Report in a Competitive Fashion that is Driving Rapid Development

The OET study finds that the adaptive equalizer performance of 8-VSB receivers is very important for reception in multipath conditions. The technology team at NxtWave agrees, and for more than two years has been focused on both the multipath problem and the problem of multiple incompatible transmission standards.[5] At its inception in 1996, NxtWave had rights to six patents from Sarnoff Corporation, including exclusive rights to Sarnoff's QAM technology and non-exclusive rights to Sarnoff's VSB technology as it existed at that time. Since its formation, NxtWave has

[5] VSB is used for digital terrestrial broadcasting; QAM is used for digital cable television; QPSK is used for digital satellite transmission; and NTSC is used for analog television.

filed for eight additional patents, with four more in preparation. The new inventions and intellectual property all relate to advances in demodulation and adaptive equalization. This high rate of invention strongly supports OET's expectation of market-driven improvements in chip and receiver technology.

The semiconductor industry is highly competitive, and consumers have benefited from enormous improvements in both cost and performance in consumer electronics and personal computing. NxtWave is not alone in introducing demodulator chips with significant performance improvements compared to the industry's first generation chips. Motorola, Philips, Oren, Broadcom, and Lucky Goldstar, among others, all have indicated substantial improvements in the technology of VSB reception.

Specifics of NxtWave's Chip Solution

NxtWave began the detailed circuit design of a multimode QAM/VSB demodulator chip in September 1998. The fundamental research and architecture studies, which preceded the detailed circuit design, began mid-year 1997.

In August 1999, NxtWave introduced its multimode QAM/VSB demodulator chip, designated the NXT2000. The chip incorporates a novel adaptive equalizer structure that increases the equalizer range while decreasing the response time compared to first generation chips. The architecture is significant because it reduces the amount of noise created by the equalizer as it adapts to dynamically changing channels. This means that the NXT2000 will be able to receive signals that first generation receivers could not.

The appendix contains photographs demonstrating indoor reception in both extreme multipath and low signal level conditions using the NXT2000 chip. This reception was accomplished using two different low-cost antennas: a bow tie and a straightened paper clip. The NxtWave facility is approximately thirty miles from the Philadelphia DTV transmission sites.

The improvements in equalizer range and lower noise are demonstrated in the results reported in the appendix. For example, with a purely Additive White Gaussian Noise (AWGN) channel, the NXT2000 achieves threshold of visibility (TOV) at 15.1 dB carrier-to-noise ratio (CNR), using blind equalization with adaptation at every symbol instance[6]. The equalizer's rapid response is demonstrated by its ability to track dynamic multipath.

Many additional features of the NXT2000 are described in an article published in the August 23, 1999, Electronic Design Magazine pp. 35-42 (attached). Specific new

[6] Footnote 8 of the Comments of Sinclair Broadcast Group, Inc. on DTV Report from the FCC Office of Engineering and Technology is incorrect. There is no threshold penalty due to the use of blind equalization. See Johnson et el., "Blind Equalization Using the Constant Modulus Criterion: A Review," *Proceedings of the IEEE,* vol. 86, no. 10, pp. 1927-50, Oct. 1998.

technologies (compared to first generation chips) include blind equalization, pilot-less demodulation, sparse coefficient allocation, and combined decoding and equalization.

Thorough and scientific evaluation of the chip's performance, both in NxtWave's laboratory and in the ATSC compliance laboratory at Zenith, validates the simulated performance described in the Electronic Design Magazine[7] article. The chip is now being evaluated, under confidentiality, with a number of receiver manufacturers. Volume production will begin late this year.

Chips Are One Component in a Receiver

The demodulator chip is one component, albeit a critical component, of a receiver system. Just as a good automotive engineer can evaluate an engine's performance and make accurate predictions about its impact on the performance of a car, so can a good communications engineer evaluate a chip's performance and make accurate predictions about its impact on the performance of a receiver. It is equally true that the performance of the system depends on the integration of a number of components. It is reasonable to expect improvements in many receiver components, including tuners, antennas, system software, and system integration.

It is possible to test and evaluate components repeatably and scientifically in a laboratory. Field-testing a demodulator chip is difficult outside the context of a well designed and built receiver (which includes other components, such as a tuner, an automatic gain control circuit, an MPEG-2 decoder, etc.). NxtWave does not design or manufacture receivers, but NxtWave's customers will.

MSTV has an extensive field-testing program, with methodology developed over a number of years. NxtWave has conducted preliminary field tests of the NXT2000 in Philadelphia and in Washington D.C. in conjunction with MSTV and its members. Field-testing indicates that 8-VSB reception is already superior to current NTSC, and that ongoing improvements in receiver design will greatly improve performance.

Conclusion

The physical limitations on COFDM and 8-VSB are well understood and described in the OET report. The performance limitations that were observed in first generation chips and receivers were determined strictly by limitation in their design and implementation, not by fundamental limitations of the 8-VSB modulation format or the FCC's DTV standard. Second generation chips, including the NXT2000, show significant improvement. Dramatic and continuous performance improvements will inevitably continue, driven by Moore's Law and market demand. There is no reason to consider modifications to the DTV transmission standard.

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[7] NxtWave's conclusions regarding the ability of 8-VSB to overcome complex multipath effects are based strictly on laboratory and field measurements together with thorough scientific analysis by recognized experts. NxtWave has never based any of its projections of 8-VSB performance on data derived from the Oak Technology data, as speculated by Sinclair in their response to the OET Report.

APPENDIX

This appendix documents some performance testing of the NXT2000. These results were produced in a controlled laboratory environment and therefore are repeatable. The appendix also includes photographs documenting indoor reception in extreme multipath and low signal environments using two different low-cost antennas: a bow tie and a straightened paper clip.

NXT2000 LABORATORY PERFORMANCE

STATIC TESTS	
AWGN	15.1 dB CNR
Ensemble A-G with AWGN	16.2-16.6 dB CNR
Strongest Static Echo	0.0 - 0.5 dB < 0.1 usec 1.5 dB at 1 usec 2.5 dB at 15 usec 3 dB at 32 usec 5 dB at 44 usec
DYNAMIC TESTS	
Single Dynamic Echo	3 dB at 0.1 usec up to 5 Hz 3.5 dB at 1 usec up to 5 Hz 4.0 dB at 1.5 usec up to 5 Hz

- AWGN tests are indicative of the demodulator's ability to receive data reliably in a low signal strength environment and are directly related to coverage area. *The NXT2000 meets or exceeds the performance of the Grand Alliance reference system for AWGN tests.*

- Ensembles A-G with AWGN tests use the multipath channel models suggested by the ATSC with the addition of the AWGN impairment. *The NXT2000 introduces less than 1.5 dB loss in the CNR required at TOV for ATSC ensemble multipath channels A-G.*

- The strongest static echo tests show the equalizer's ability to compensate for severe multipath conditions ranging up to 44 microseconds.

- A single echo is dynamically phase shifted at a Doppler rate of up to 5 Hz. These tests model most indoor signaling conditions, and *the NXT2000 is capable of tracking the changing echoes.*

Each of the following pictures was taken in an indoor setting approximately 30 miles from the transmitters in Philadelphia. The photographs show the decoded TV picture, the receiving antenna (either a bow-tie or straightened paper clip), and a spectrum analyzer showing the RF received spectrum.

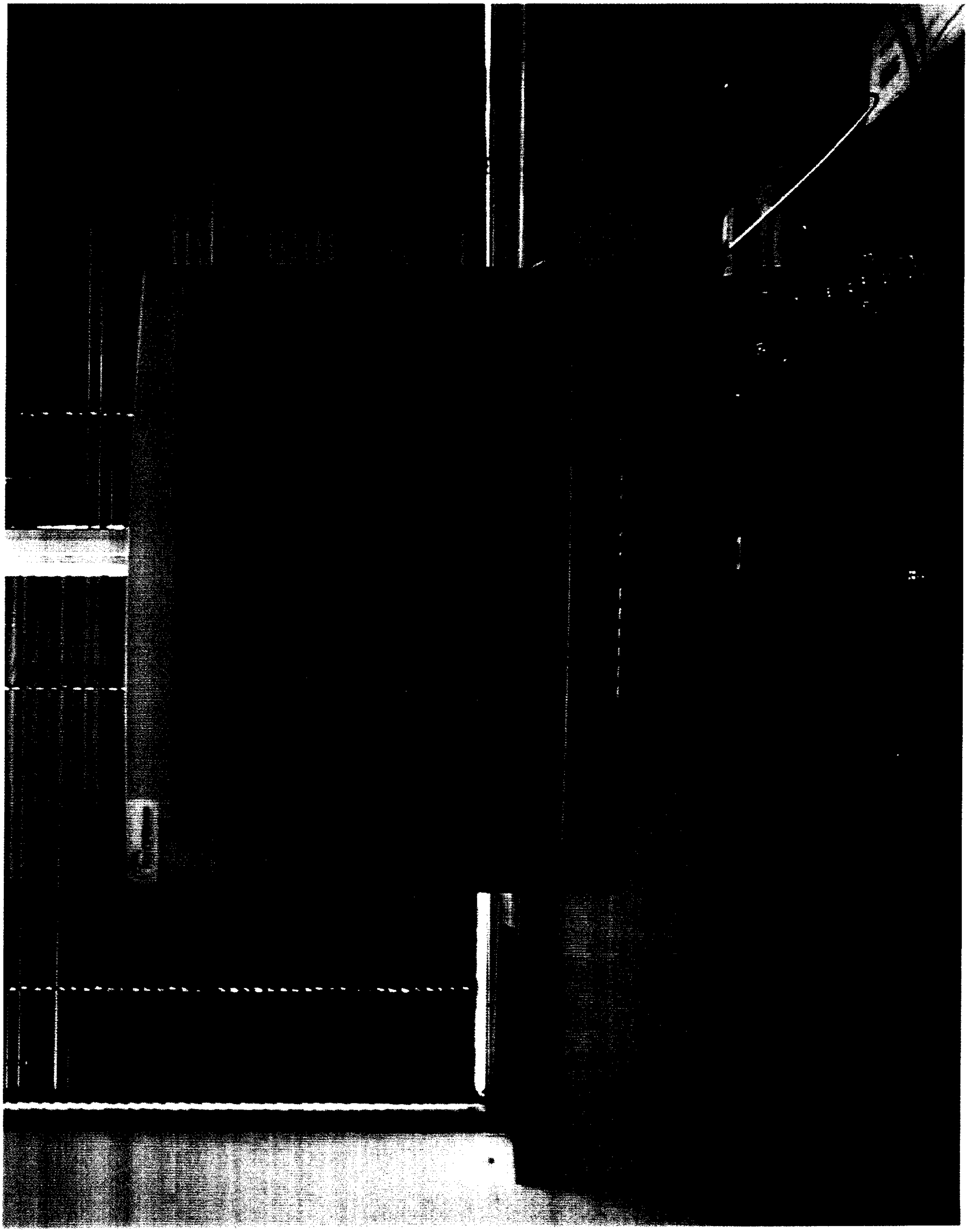
Photograph 1: This picture illustrates successful reception with severe multipath (note the deep notch in the left-center of the band). The antenna is a standard UHF bow-tie.

Photograph 2: This picture illustrates successful reception with severe multipath (note the deep notch in the center of the band). In this case, however, the receiving antenna is a straightened paper clip hanging over the monitor.

Photograph 3: This picture illustrates successful reception with multipath and a low signal-to-noise-ratio. The antenna is a standard UHF bow-tie.

Photograph 1:

This picture illustrates successful reception with severe multipath (note the deep notch in the left-center of the band). The antenna is a standard UHF bow-tie.



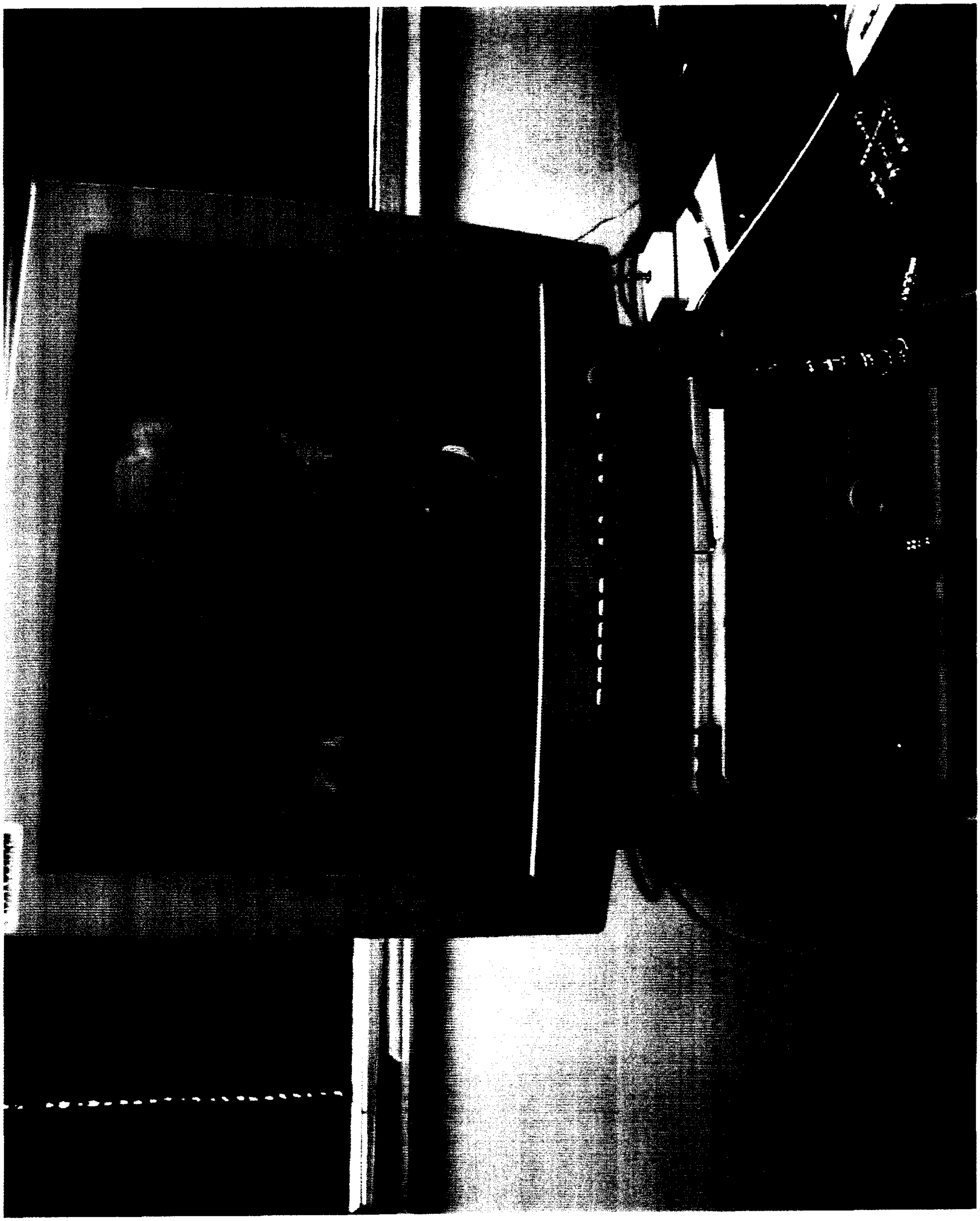
Photograph 2:

This picture illustrates successful reception with severe multipath (note the deep notch in the center of the band). In this case, however, the receiving antenna is a straightened paper clip hanging over the monitor.


Ford
610-539-5400
Ridge Pike and Trooper Road

Photograph 3:

This picture illustrates successful reception with multipath and a low signal-to-noise-ratio. The antenna is a standard UHF bow-tie.



ATTACHMENTS

Attachment 1

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NxtWave Communications Secures $13.6 Million In Second Venture Funding Round

Investments to Aid Chip Developer's Mission to Bring High-Speed Digital Communications to Consumers

Newtown, PA, September 20, 1999 – NxtWave Communications, Inc., which designs and markets broadband-communications integrated circuits (ICs) for use in digital televisions, digital video recorders, personal computers and cable modems, announced today that it has concluded its second equity round in which $13.6 million in venture capital was raised. The investment round, which was led by Venture First Associates, included additional investment by first-round investors Blue Rock Capital, Mid-Atlantic Venture Funds and Oak Investment Partners. Anadigics Inc., Dimensional Partners, Intel Corporation, Pequot Capital Management's venture fund, PS Capital Ventures, L.P and J. H. Whitney & Company also participated in the financing. Further financial details of the investment were not disclosed.

The latest funding will be used to finance company growth through a number of business activities including the introduction and marketing of the company's new

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VSB/QAM demodulator for digital television. Funds raised will also be used for general corporate purposes.

Matt Miller, president and CEO of NxtWave Communications, said, "We are pleased to have attracted high-quality investors to fund our next stage of growth. We believe that the funds and support that we received increases our ability to achieve our objective of providing the marketplace with high-performing, feature-rich and cost effective semiconductors for broadband communication applications. We also believe that we are especially well positioned to play a major industry role in the worldwide transition from analog to digital television."

"We saw in NxtWave Communications the vision, ability and depth of knowledge to bring a new breed of semiconductor products to the dynamic and emerging video and data communication markets," said W. Andrew Grubbs, general partner at Venture First Associates.

About NxtWave Communications, Inc.

NxtWave Communications Inc. of Newtown, Pennsylvania, is a privately held digital broadband communications company. Using efficient and robust modulation and demodulation techniques, the company's integrated circuit solutions satisfy the requirements of manufacturers of cable modems, interactive set-top boxes, digital TVs, PC TVs and digital telephony. NxtWave Communications leverages proprietary algorithms in its receiver implementations of industry standard transmission formats including QAM, VSB, QPSK and NTSC. NxtWave Communications, Inc., is headquartered at 6 Penns Trail, Newtown, Pennslvania, 18940, with worldwide marketing and sales headquartered at 6 Venture, Suite 350, Irvine, California, 92618. For additional information visit nxtwavecomm.com

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